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BEHAVIOUR OF TERNARY BLENDED CONCRETES WITH DIFFERENT WATER BINDER RATIOS

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ABSTRACT

Many researchers have studied the properties of ordinary Portland cement concrete by using mineral admixtures like fly ash, micro silica rise husk ash, GGBS as cement replacement materials. A few researchers have done work for triple blended concrete’s using mineral admixtures like micro silica, fly ash. Mineral admixtures are used in order to increase strength and to improve durability of concrete. Blast furnace slag, fly ash and micro silica are some of the mineral admixtures used in varying proportions to achieve such results. The mineral admixtures also affect the properties of concrete in fresh state, rate of strength development and durability in hardened state. Economics and environmental considerations are the key factors in the growth of mineral admixture usage. Micro silica together with super plasticizer is generally used in concrete to enhance strength and durability. Due to its finer size and higher pozolanicity compared to other mineral additives, micro silica incorporation leads to improved mechanical properties of concrete even at early ages. Fly ash, on other hand, as mineral admixture in concrete, enhances its workability, long-term strength and durability. It is generally believed that high strength concretes are achievable only through the addition of micro silica. However, micro silica is relatively expensive compared to cement, especially in countries like India where it is imported. Fly ash on other hand is easily available at lower cost than cement. Moreover, micro silica due to its fine particle size increases the water demand and has tendency to consume higher dosage of superplasticizer, whereas, fly ash due to presence of spherical particles that easily rollover one another reducing inner particle friction (called ball bearing effect) leads to improved workability and reduction in water demand. Due to associated environmental pollution caused in the production of the cement to reserve the virgin raw material used in cement making for future generations and at the same time due to the availability of supplementary cementations like fly ash, micro silica etc. An attempt had been made to study the strength properties of ternary blended concrete for various w/b ratios of 0.55, 0.45 and 0.35 for 28, 90 and 180 days.

KEYWORDS: Water Binder Ratio, Ternary Blended Concretes, Compressive Strength, Split Tensile Strength, Flexural Strength.

INTRODUCTION

During the last three decades, some new Pozzolana materials have emerged in the building industry as an off shoot of research aimed at energy conservation and strict enforcement of pollution control measures to stop dispersing the materials into the atmosphere. Silica fume (other names have been used are silica dust, condensed silica fumes and micro silica) is one such Pozzolana, which has been used as a partial replacement of Portland cement due to its versatile properties. The availability of high range water-reducing admixtures (super plasticizers) has opened up new ideas for the use of silica fume as part of the cementing material in concrete to produce very high strength cement (> 100 MPa/15,000 psi). Silica fumes or micro silica is a by-product from the reduction of high purity quartz with coal in electric arc furnaces

in the manufacture of silicon and ferrosilicon alloys. The fume, which has a high content of amorphous SiO_2 and is consisted of very fine spherical particles, is collected from the gases escaping from the furnaces. Silica fume is also collected as a by-product in the production of other silicon alloys such as ferrochrome, ferromanganese and ferrovanadium.

Micro silica is predominantly silicon dioxide. Its prime characteristic is particle size which would be as low as 0.2 micron, which is about 100 times smaller than Portland cement grains. The extremely small grain size of micro silica is responsible for its high reactivity with free lime in the concrete to form a strong and non-permeable paste. The other important properties which established micro silica as a formidable building material are its imperviousness to water, low permeability to chloride ion and resistant to sulfate and acid attack. Because of high surface area and high contents of amorphous silicon in silica fumes, the latter acts as a highly active Pozzolan and reacts more quickly than ordinary Pozzolans.

The Pozzolanic reaction may begin as early as 2 days after cement hydration and the main Pozzolanic effect of silica fume in concrete takes place between the ages of 3 and 28 days for curing at 20^o C. The presence of silica fumes provides increased internal cohesion of fresh concrete. As a result, local areas of weakness such as bleed water channels and voids under coarse aggregate particles can be eliminated. The transition zone between cement paste and coarse aggregate particles is an especially critical region in most concrete. It is frequently the weakest part because of bleed-water voids, so it is under the greatest stress because of the elastic bond between the cement paste and the relatively stiff aggregate material.

The presence of micro silica brings reduction of bleeding in fresh concrete and in consequences, significant improvements in the density of the transition zone and in the mechanical behavior of hardened concrete. The strength of the transition zone can be further enhanced by a Pozzolanic reaction.

LITERATURE REVIEW

Tahir Kemal Erdem et.al[1] discussed the combinations of cement additions may provide more benefits for concrete than a single one. Results indicated that ternary blends almost always made it possible to obtain higher strengths than Portland cement + silica fume binary mixtures provided that the replacement level by the additions was chosen properly. Moreover, the performance of slag in the ternary blends was better than Class F fly ash but worse than Class C fly ash. **M.D.A. Thomasa et.al**[2] presented the test results from laboratory studies on the durability of concrete that contains ternary blends of Portland cement, silica fume, and a wide range of fly ashes. In this study it was shown that replacement levels of up to 60% were required to control expansion due to ASR with some fly ashes. However, combinations of relatively small levels of silica fume (e.g., 3 to 6%) and moderate levels of high CaO fly ash (20 to 30%) were very effective in reducing expansion due to ASR and also produced a high level of sulphate resistance. Concretes made with these proportions generally show excellent fresh and hardened properties since the combination of silica fume and fly ash is somewhat synergistic. For instance, fly ash appears to compensate for some of the workability problems often associated with the use of higher levels of silica fume, whereas the silica fume appears to compensate for the relatively low early strength of fly ash concrete. Diffusion testing indicates that concrete produced with ternary cementitious blends has a very high resistance to the penetration of chloride ions. Furthermore, these data indicate that the diffusivity of the concrete that contains ternary blends continues to decrease with age. The reductions are very significant and have a considerable effect on the predicted service life of reinforced concrete elements exposed to chloride environments. **Roland Bleszynski et.al**[3] investigated on the durability of Ternary cementitious systems. Seven concrete mixtures, including three ternary concrete mixtures consisting of various combinations of silica fume, blast-furnace slag, and Portland cement were studied. **Shweta**

Goyal et.al[4] investigated on the role of fly ash addition on superplasticizer dosage, slump and 28 day and 90 day compressive strength of silica fume concrete is investigated in this work. **A.K.Mullck et.al**[5] described the characteristics of cementitious systems required to meet the diverse requirements of strength and durability of concrete and highlights the advantages of part replacement of OPC by fly ash, granulated slag and silica fume- either singly or in combination in ternary blends. **M.I. Khan et.al**[6] described the results form part of an investigation into the optimization of a ternary blended cementitious system based on ordinary Portland cement (OPC)/ pulverized fuel ash (PFA)/ silica fume (SF) for the development of high- performance concrete. **Mohd Shariq et.al**[7] discussed the compressive strength properties, when GGBFS is used to make concrete and discuss in detail the compressive strength development of concrete cubes and cylinders.

A comparative study has also been carried out between the experimentally obtained compressive strength and strength predicted by the models given in SP-24 (Indian Standard), ACI-209, CEB-FIP and GL-2000. Based on the experimentally obtained results a strength predicting models has also been proposed for GGBFS based concrete. **Tahir Kemal Erdem et.al**[8] indicated that ternary blends almost always made it possible to obtain higher strengths than Portland cement + silica fume binary mixtures provided that the replacement level by the additions was chosen properly. Moreover, the performance of slag in the ternary blends was better than Class F fly ash but worse than Class C fly ash. **Men_endez et.al**[9] discussed on the benefits of limestone filler (LF) and granulated blast-furnace slag (BFS) as partial replacement of Portland cement. LF addition to Portland cement causes an increase of hydration at early ages inducing a high early strength, but it can reduce the later strength due to the dilution effect. On the other hand, BFS contributes to hydration after seven days improving the strength at medium and later ages. A statistical analysis is presented for the optimal strength estimation considering different proportions of LF and BFS at a given age. The use of ternary blended cements (PC–LF–BFS) provides economic and environmental advantages by reducing Portland cement production and CO2 emission, whilst also improving the early and the later compressive strength.

EXPERIMENTAL INVESTIGATION

The present investigation is aimed to study the strength properties of ternary blended concrete's using micro silica and fly ash for various w/b ratios of 0.55, 0.45 and 0.35 for 28, 90 and 180 days

MATERIALS

Cement

Ordinary Portland cement of 53 grade having specific gravity of 3.02 and fineness of 3200cm^2/gm was used. The Cement used has been tested for various proportions as per IS 4031-1988 and found to be confirming to various specifications of 12269-1987.

Coarse Aggregate

Crushed angular granite metal of 10 mm size having the specific gravity of 2.65 and fineness modulus 6.05 was used.

Fine Aggregate

River sand having the specific gravity of 2.55 and fineness modulus 2.77 was used.

Fly Ash

Type-II fly ash confirming to I.S. 3812 – 1981of Indian Standard Specification was used.

Micro Silica

The Micro silica having the specific gravity 2.2 was used.

Superplasticizer

Super plasticizer CONPLAST 430 was used as water reducing admixture.

DISCUSSIONS OF RESULTS

Mix Proportions

Table 1.0 and 2.0 gives the mix portions of ordinary concretes as well as Ternary Blended Concrete with 5% Micro Silica and 15% Fly Ash replacement of Cement.

Compressive Strength of Ordinary and Ternary Blended Concrete

From Table 3.0 it is observed that Compressive Strength values of Ordinary Concrete varied from 35.2 to 60.4 MPa for 28 days, 37.42 to 66.72 MPa, for 90 days and 40.44 to 73.24 MPa for 180 days. These variations are given in graph 1.

From Table 4.0 it is observed that Compressive Strength value of Ternary Blended Concrete varied from 39.44 to 74.78 MPa for 28 days 44.87 to 85.00 MPa for 90 days and 48.81 to 96.70 MPa for 180 days. These variations are given in graph 2.

Split Tensile Strength of Ordinary Concrete and Ternary Blended Concrete

From Table 5.0 it is observed that the Split Tensile Strength values of Ordinary Concrete varied from 1.02 to 1.64 MPa for 28 days, 1.32 to 2.24 MPa for 90 days and 1.53 to 2.67 MPa for 180 days .These variations are given in graph 3.

From Table 6.0 it is observed that the Split Tensile Strength values of Ternary Blended Concrete varied from 1.18 to 1.95 MPa for 28 days, 1.58 to 2.77 MPa for 90 days and 1.83 to 2.99 MPa for 180 days. These variations are given in graph 4.

Flexural Strength of Ordinary Concrete and Ternary Blended Concrete

From Table 7.0 it is observed that the Flexural Strength values of Ordinary Concrete varied from 6.13 to 6.39 MPa for 28 days, 7.07 to 8.12 MPa for 90 days and 7.35 to 8.32 MPa for 180 days. These variations are given in graph 5.

From Table 8.0 it is observed that the Flexural Strength values of Ternary Blended Concrete varied from 6.87 to 7.67 MPa for 28 days, 8.49 to 10.15 MPa for 90 days and 8.53 to 10.37 MPa for 180 days. These variations are given in graph 6.

Variation of Compressive Strength Split Tensile Strength and Flexural Strength of Ternary Concrete Mixes Compared with Ordinary Concrete Mixes

From Table 9.0, 10.0 and 11.0 the variation in Compressive Strength , Split Tensile Strength and Flexural Strength of Ternary Blended Concrete is 10 to 30 % in comparison with Ordinary Concrete at 28, 90 and 180 days.. These variations are observed in graph 7, 8, and 9.

The improved performance of Ternary Blended Concrete could be attributed to the improvement in the bond between the hydrated cement matrix and aggregate. This in turn is due to the combined effect of secondary pozzolanic

reaction and the fineness of micro silica particles. The combination of micro silica and fly ash leads to increase in compressive strength as compared to control mix irrespective of water to binder ratios.

Variation of Compressive Strength Split Tensile Strength and Flexural Strength of Ternary Concrete Mixes Compared with 28 Days Strength

From Table 12.0, 13.0 and 14.0 it is observed that in increase in strength of Ternary Blended Concretes in comparison with 28 days to be 10 to 30 % in Compressive Strength, 30 to 50 % in Split Tensile Strength and 20 to 35 % in Flexural Strength. These variations are observed in graph 10, 11, and 12.

CONCLUSIONS

In Ternary Blended Concrete micro silica act as filler and fly ash controls the workability. Therefore, this combination is more effective in improving the properties of Ternary Blended Concrete. The combination of micro silica and fly ash leads to increase in Compressive Strength , Split Tensile Strength , Flexural Strength as compared to control mix irrespective of water to binder ratios. The percentage increase of compressive strength of ternary blended concrete is 10 to 30%., in Split Tensile Strength 15 to 27 % and in Flexure 10 to 30 % when compared with Ordinary Concrete .The percentage increase of Ternary Blended Concretes is 10 to 30% in Compression, 30 to 50 % in Split Tensile and 20 to 35 % in Flexure when compared with 28 days strength .

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APPENDICES

Table 1: Quantities of Materials Required Per 1 M^3 of Ordinary Concrete

S.No	W/C	Cement	Fine Aggregate.	Coarse Aggregate	Water	Super Plasticizer
1	0.55	324	736	1084	178	0
2	0.45	391	697	1070	176	0
3	0.35	497	629	1050	174	3480

Table 2: Quantities of Material Required Per 1 M^3 of Ternary Blended Concrete (5% Micro Silica – 15% Fly Ash)

S.No	W/B	Cement	Micro Silica	Fly Ash	Fine Aggregate.	Coarse Aggregate	Water	Super Plasticizer
1	0.55	259	16.20	48.6	736.0	1084.0	178	0
2	0.45	312	`19.55	58.65	697.0	1070.0	176	0
3	0.35	397	24.85	74.55	629.0	1050.0	174	2980

Table 3: Compressive Strength of Ordinary Concrete at 28, 90, 180 Days

S.No	W/C Ratio	Compressive Strength (MPa)		
		28 Days	90 Days	180 Days
1	0.55	35.20	37.42	40.44
2	0.45	42.32	45.61	49.42
3	0.35	60.04	66.72	73.24

Table 4: Compressive Strength of Ternary Blended Concrete at 28, 90, 180 Days

S.No	W/B Ratio	Compressive Strength (MPa)		
		28 Days	90 Days	180 Days
1	0.55	39.44	44.87	48.81
2	0.45	50.22	57.00	63.73
3	0.35	74.78	85.00	96.70

Table5: Split Tensile Strength of Ordinary Concrete at 28, 90, 180 Days

S.No	W/C Ratio	Split Tensile (MPa)		
		28 Days	90 Days	180 Days
1	0.55	1.02	1.32	1.53
2	0.45	1.52	2.02	2.45
3	0.35	1.64	2.24	2.67

Table 6: Split Tensile Strength of Ternary Blended Concrete: at 28, 90, 180 Days

S.No	W/B Ratio	Split Tensile Strength (MPa)		
		28 Days	90 Days	180 Days
1	0.55	1.18	1.58	1.83
2	0.45	1.78	2.44	2.76
3	0.35	1.95	2.77	2.99

Table 7: Flexural Strength of Ordinary Concrete at 28, 90, 180 Days

	W/C Ratio	Flexural Strength (MPa)		
		28 Days	90 Days	180 Days
1	0.55	6.13	7.07	7.35
2	0.45	6.24	7.62	7.82
3	0.35	6.39	8.12	8.32

Table 8: Flexural Strength of Ternary Blended Concrete at 28, 90, 180 Days

S.No	W/B Ratio	Flexural Strength (MPa)		
		28 Days	90 Days	180 Days
1	0.55	6.87	8.49	8.53
2	0.45	7.16	9.03	9.26
3	0.35	7.67	10.15	10.37

Table 9: Percentage Increase in Compressive Strength of Ternary Blended Concrete with Respect to Ordinary Concrete

S.No	W/B Ratio	28 Days	90 Days	180 Days
1	0.55	13.47	19.9	20.76
2	0.45	18.69	24.97	28.93
3	0.35	23.82	27.38	32.03

Table 10: Percentage Increase in Split Tensile Strength of Ternary Blended Concrete with Respect to Ordinary Concrete

S.No	W/B Ratio	28 Days	90 Days	180 Days
1	0.55	15.45	19.86	23.40
2	0.45	16.74	21.04	24.54
3	0.35	18.58	23.81	27.05

Table 11: Percentage Increase in Flexural Strength of Ternary Blended Concrete with Respect to Ordinary Concrete

S.No	W/B Ratio	28 Days	90 Days	180 Days
1	0.55	10.64	12.07	19.19
2	0.45	16.75	18.70	24.72
3	0.35	19.93	24.94	27.94

Table 12: Percentage Increase in Compressive Strength of Ternary Blended Concrete with Respect to 28 Days Strength

S.No	W/B Ratio	90 Days	180 Days
1	0.55	12.35	22.23
2	0.45	13.66	26.91
3	0.35	14.67	29.32

Table 13: Percentage Increase in Split Tensile Strength of Ternary Blended Concrete with Respect to 28 Days Strength

S.No	W/ B Ratio	90 Days	180 Days
1	0.55	34.16	38.45
2	0.45	37.42	43.80
3	0.35	42.32	48.50

Table 14: Percentage Increase in Flexural Strength of Ternary Blended Concrete with Respect to 28 Days Strength

S.No	W/ B Ratio	90 Days	180 Days
1	0.55	20.36	24.23
2	0.45	26.16	29.43
3	0.35	32.42	35.29

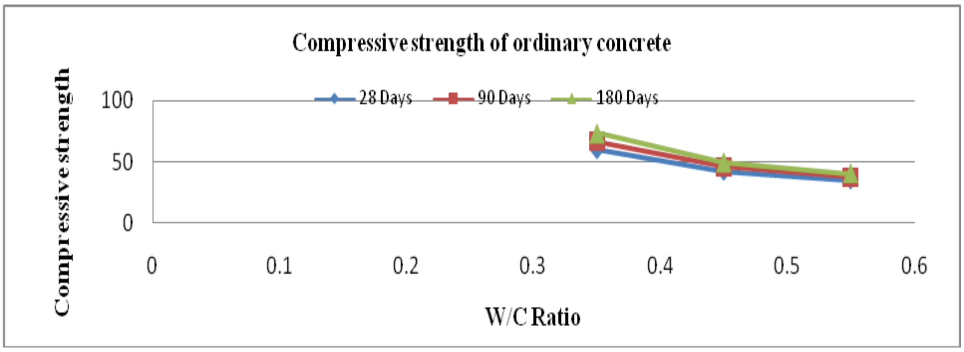

Figure 1: Compressive Strength of Ordinary Concrete vs W/C Ratio

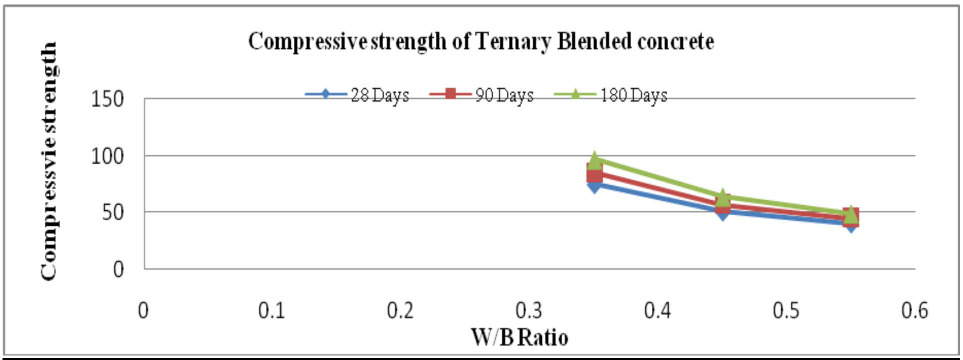

Figure 2: Compressive Strength of Ternary Blended Concrete vs W/B Ratio

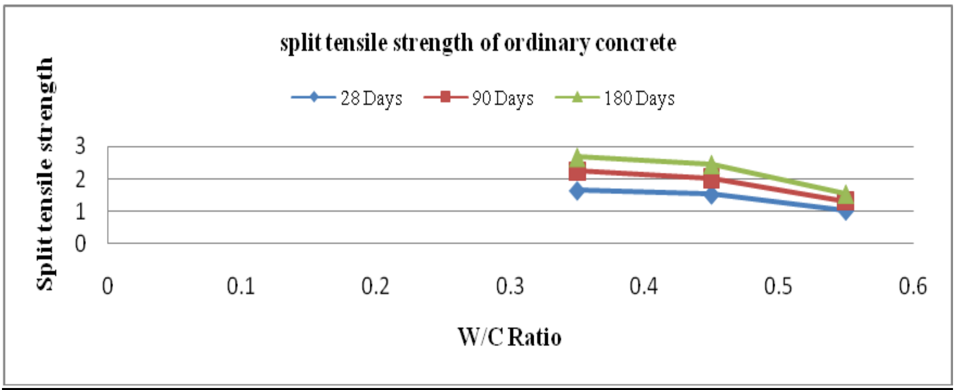

Figure 3: Split Tensile Strength of Ordinary Concrete vs W/C Ratio

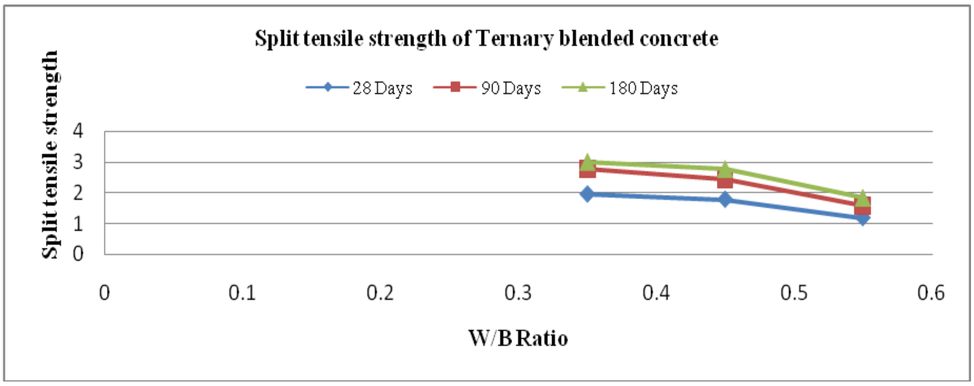

Figure 4: Split Tensile Strength of Ternary Blended Concrete vs W/B Ratio

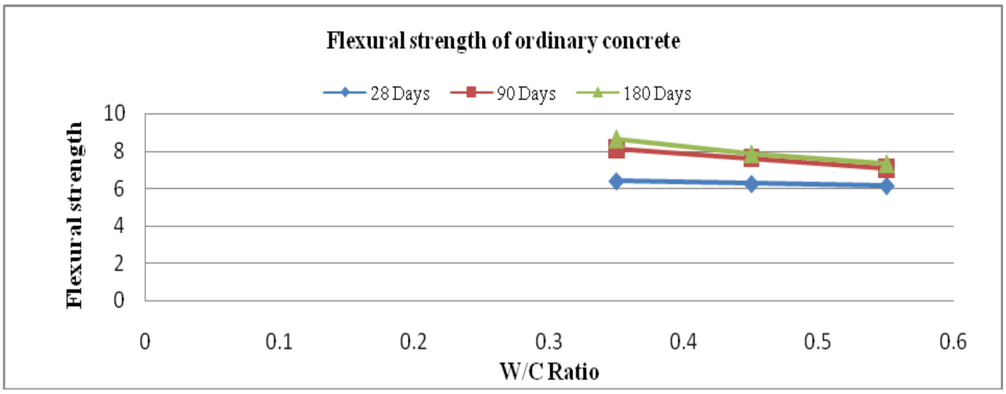

Figure 5: Flexural Strength of Ordianry Concrete vs W/C Ratio

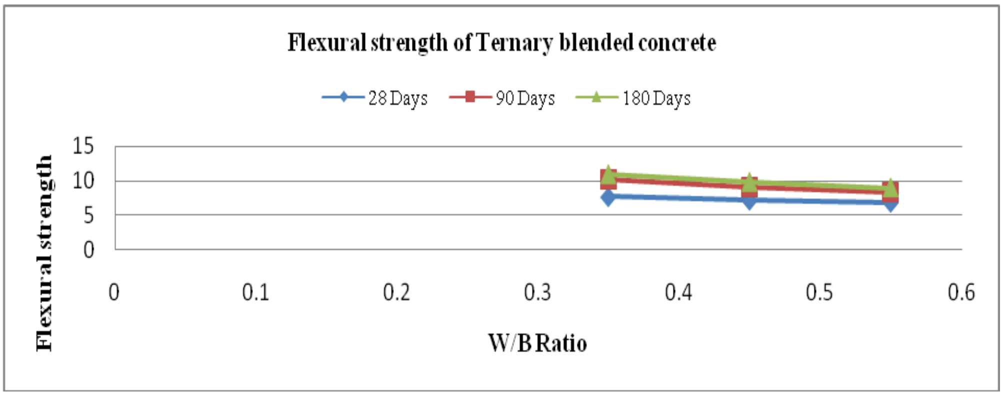

Figure 6: Flexural Strength of Ternary Blended Concrete vs W/B Ratio

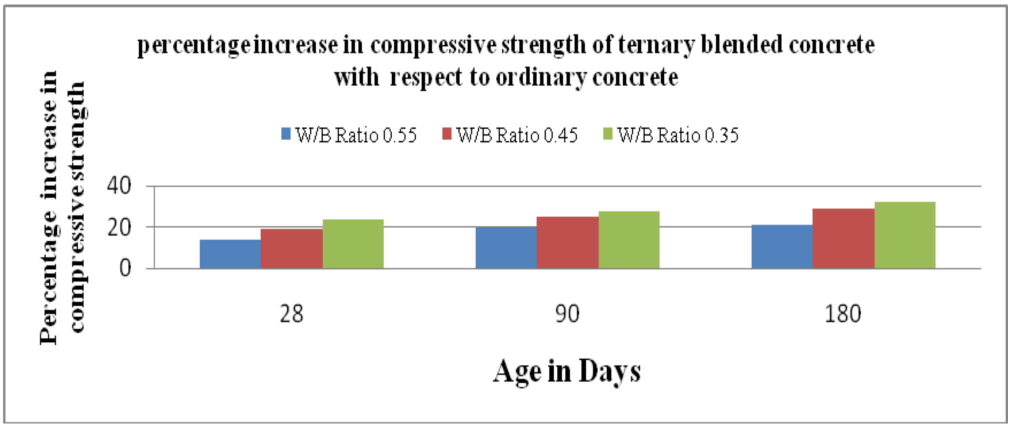

Figure 7: % Increase in Compressive Strength of Ternary Blended Concrete with Respect to Ordinary Concrete

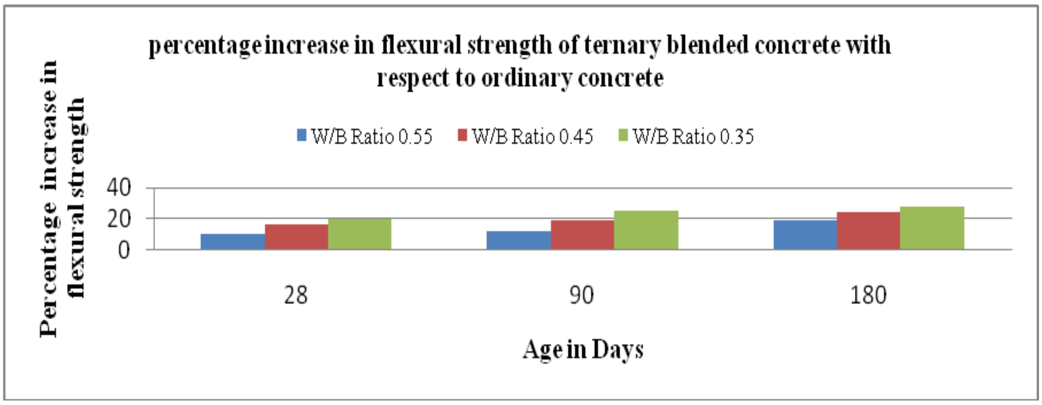

Figure 8: % Increase in Split Tensile Strength of Ternary Blended Concrete with Respect to Ordinary Concrete

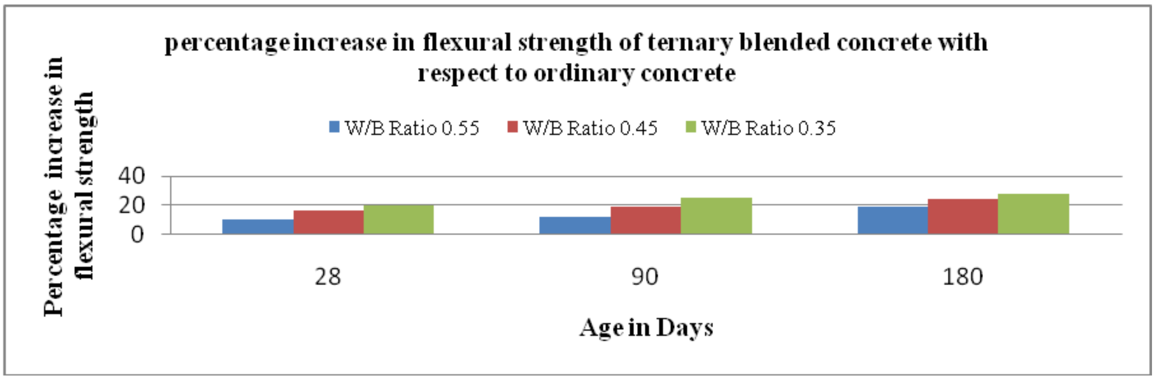

Figure 9: % Increase in Flexural Strength of Ternary Blended Concrete with Respect to Ordinary Concrete

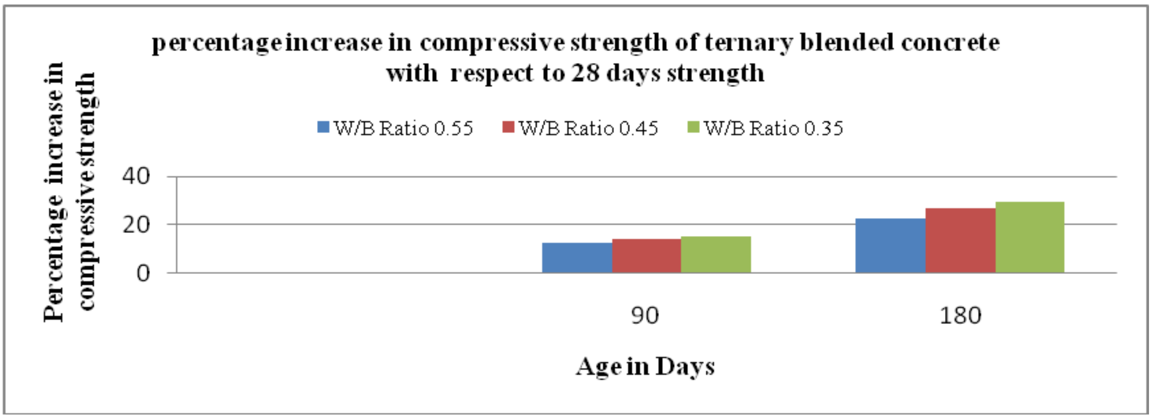

Figure 10: % Increase in Compressive Strength of Ternary Blended Concrete with Respect to 28 Days Strength

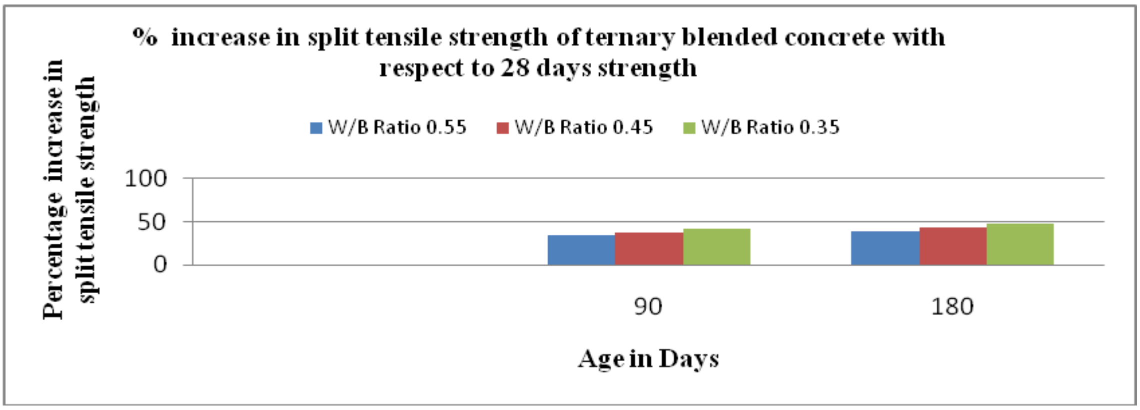

Figure 11: % Increase in Split Tensile Strength of Ternary Blended Concrete with Respect to 28 Days Strength

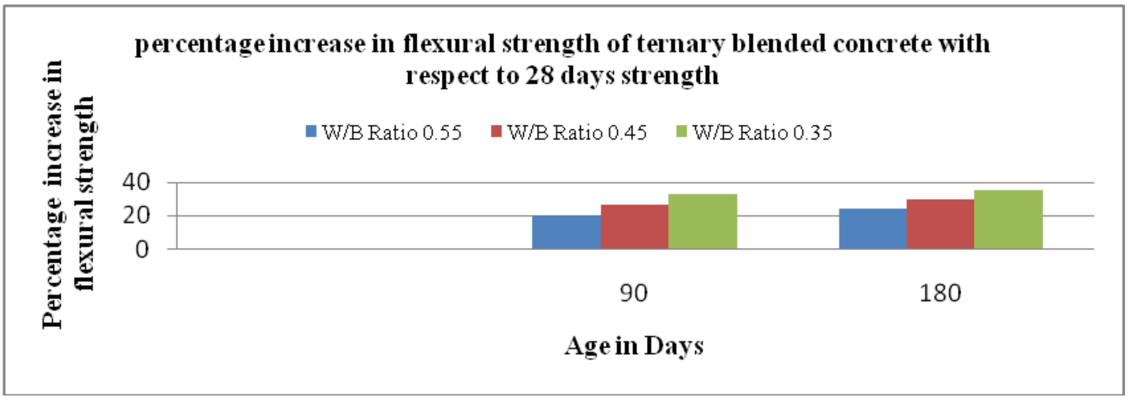

Figure 12: % Increase in Flexural Strength of Ternary Blended Concrete with Respect to 28 Days Strength

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